UCN-7721B
(2 1-86)

OAK RIDGE Y-12 PLANT INFORMATION CONTROL FORM

5/27

DOCUMENT DESCRIPTION (Completed By Requesting Division)

Document No.	Author's Telephone No.	Acct. No.	Date of Request
Y-531	6-0263	23366-0002	5/17/96

Unclassified Title: PROTECTIVE EQUIPMENT EVALUATION PROGRAM - QUARTERLY PROGRESS REPORT (JULY - SEPTEMBER 1949)

Author(s) Requested by Steve Wiley

TYPE ☐ Formal Report ☐ Informal Report ☐ Progress/Status Report ☐ Co-Op Report ☐ Thesis/Term Paper

☐ Oral Presentation (identify meeting, sponsor, location, date):

☐ Journal Article (Identify Journal):

☒ Other (Specify): To Be Released for Phase II of HSA

Document will be published in proceedings ☑ No ☐ Yes

Document will be distributed at meeting ☑ No ☐ Yes

Document has patent or invention significance ☑ No ☐ Yes (Identify)

Document has been previously released ☑ No ☐ Yes (Reference)

DIVISION REVIEW AND APPROVAL (Completed By Requesting Division)

TECHNICAL CLASSIFICATION REVIEW (Divisional Classification Representative)

Title(s): U Abstract: NA

DOCUMENT: Level U Category —

[signature] Signature 5/21/96 Date

DOCUMENT REQUEST APPROVED (Division or Department)

[signature] Signature 5/17/96 Date

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Y-12 Central Files Y-12 RC Y-12 RC Y-12 RC

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2 CLASSIFICATIONS:

Title(s): U Abstract —

DOCUMENT:

Level U* Category —

Weapon Data — Sigma —

[signature] Y-12 Classification Office 5/21/96 Date

☐ Editor Date

3 Patent Office [signature] 5/22/96

4 Reld. K25 CO 5/23/96 Unclassified w/regard to K-25 site matters D.G. Gilliland for A.S. Quist 5/23/96 Date

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PROTECTIVE EQUIPMENT EVALUATION PROGRAM QUARTERLY PROGRESS REPORT

JULY 1, 1949 TO SEPTEMBER 30, 1949

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SPECIAL REREVIEW
FINAL
DETERMINATION:
UNCLASSIFIED
DATE: 7-7-80 JEK

DECLASSIFICATION
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CLASSIFICATION
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1979

-1139 (Rev. 8-48)

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CARBIDE AND CARBON CHEMICALS CORPORATION
Y-12 PLANT
Contract No. W-7405-Eng-26

Y-12 RESEARCH LABORATORY
Dr. E. D. Shipley, Director

PROTECTIVE EQUIPMENT EVALUATION PROGRAM
(In Cooperation with the Army Chemicals Corps)
E. G. Struxness, Group Leader

QUARTERLY PROGRESS REPORT
July 1, 1949 to September 30, 1949

CLASSIFICATION CHANGED TO Unclassified
BY AUTHORITY OF
BY M.P.M.Kenty DATE 11/3/71

CONFIDENTIAL
UNDOCUMENTED

CLASSIFICATION CHANGED TO
BY AUTHORITY OF TID-1155 (8-15-57)
BY Betty E. Rose DATE 9-4-57

Oak Ridge, Tennessee
December 15, 1949

SECRET

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applicable Federal laws.

Index No. Y-531
Internal

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HISTORICAL DEVELOPMENT OF THE PROGRAM

In May of 1948, representatives of the Atomic Energy Commission and the Carbide and Carbon Chemicals Corporation met with representatives of the Army Chemical Corps to discuss the possibility of jointly sponsoring a program of research and development in the field of filters, filtering devices, protective devices, protective clothing and other problems relating to personnel and collective protection against atomic warfare. It was indicated at this conference that such a program would be of interest and benefit to the Atomic Energy Commission in view of current problems with regard to waste disposal and personnel protection.

Following a similar meeting in June, Dr. C. E. Larson (C&CCC) submitted a proposal for a development program on filters.[1] Further negotiations led to a revised proposal by the same author in October 1948.[2]

A final organization meeting was held at Oak Ridge on March 30, 1949, with AEC, C&CCC, and Chemical Corps representatives in attendance at which time the initial phase of the program was discussed in terms of one year only. The following excerpt is taken from a memorandum which summarized the decisions made at the March 30 meeting:[3]

"The scope of the program for the first year is as follows:

A. The correlation of tracer techniques with present Chemical Corps methods.
   1. Particulate Phase (0.1 to 10 microns).
      a. Solid
      b. Liquid
   2. Gaseous Phase

B. Determination of radioactivity levels to which the results in A, above, can be extended.

C. Development of standard laboratory techniques for the determination of the effectiveness of protective devices and their components.

D. Decontamination - Literature search and assembly of information on the decontamination of personnel, building materials, and equipment available at the various AEC installations."

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(1) Larson, C. E., "A Proposed Filter Development Program", C&CCC, Y-AO-221, July 6, 1948.

(2) Larson, C. E., "Filter Development Program", C&CCC, Y-272, October 27, 1948.

(3) Larson, C. E., "Memorandum to H. M. Roth, ORDO", C&CCC, April 1, 1949.

This program was similarly set forth in correspondence between the Army Chemical Corps and the Washington Office of the Atomic Energy Commission.[4]

Final approval for the establishment of the program as outlined above was contained in a memorandum from R. W. Cook, Manager of Oak Ridge Operations of the Atomic Energy Commission to C. E. Center, General Superintendent of Carbide and Carbon Chemicals Corporation, dated July 1, 1949. This authorization established the program on a one-year basis with certain limitations on men, money, and facilities. The participation of the Chemical Corps was expected to equal that of the Atomic Energy Commission and would be limited only by their own interests and the existence of suitable facilities.

(4) Memorandum from J. P. Mitchell, Army Chemical Corps, to Mr. DeBever, Washington Office of Atomic Energy Commission, dated April 1, 1949.

ORIENTATION CONFERENCES

Introduction

It was recognized at the outset that this cooperative effort offered a fine opportunity for the effective investigation of problems of mutual interest. The diverse experience of these two groups, when mutually recognized, should accelerate the prosecution of the initial program. With this purpose in mind a series of conferences were held during the month of August and early September, at which representatives of the Chemical Corps, the Atomic Energy Commission, and the three Oak Ridge Operations were given an opportunity to discuss their respective problems and experience in the removal of toxic gases and particulates from air streams.

This section contains a summary of the discussions which took place at these conferences. It was not intended that these discussions should center on the proposed first year program, but rather to cover, generally, the field which has to do with individual and collective protection against gases and particulates. This would tend to develop a better understanding of the potential benefits to be derived from a study of filters and filtering devices as related to both Chemical Corps and Atomic Energy Commission applications.

Conference Participants

Atomic Energy Commission ----------------	J. W. Ruch
Chemical Corps ----------------------------	Lt. Col. H. P. McCormick
	J. W. Thomas
C&CCC(ORNL) ---------------------------	C. P. Coughlen
	J. W. Gost
	Dr. L. T. Newman
	I. Spiewak
C&CCC (K-25) ---------------------------	A. F. Becher
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	C. L. Stewart
C&CCC(Y-12) ----------------------------	Dr. C. E. Larson
	Dr. E. D. Shipley
	E. C. Long, Jr.
	J. W. Morfitt
	R. G. Orrison
	R. L. Quinn
	C. L. Schuske
	E. G. Struxness

Filtration Theory - J. W. Thomas

Large size particles, over about 1 micron, are removed mechanically, i.e., by impact. The removal of smaller particles is due largely to Brownian motion. There is an optimum particle size for filter penetration, and for the Cml. Corps type paper filters, this size is about 0.2 -0.3 microns. The optimum size for penetration is a function of the linear velocity of the smoke and the size of the fiber and penetrating particles.

The penetration and filters by a homogeneous smoke is conveniently expressed by an exponential function:

$$N = N_o e^{-kx}$$

where

N_o = original smoke concentration

N = concentration after passing through the filter

k = a constant depending on both filter structure and velocity of the incoming smoke

x = thickness of filter

Liquid smokes are, in general, more penetrating than solid smokes since they tend to deteriorate the filter. Solid smokes build up on the filter paper causing a decrease in penetration with time.

At the flows encountered in gas mask work the pressure drop through a filter is directly proportional to the flow rate.

For very fine fiber filters, Langmuir states that the penetration is, to a first approximation, independent of the flow rate through the filter.

Methylene Blue Test - J. W. Thomas

Filters are evaluated against solid smokes by using the methylene blue test. Methylene blue (m.b.) is a dye, $C_{16}H_{18}N_3ClS \cdot 3H_2O$. The solid heterogeneous smoke is generated by atomizing a solution of m.b. in water. The mass concentration obtained is about 25 micrograms per liter of smoke. The smoke penetrating the filter is collected on a small test filter paper strip. Standard aliquots of the unfiltered smoke are similarly collected and compared to the penetration stain. The aliquot of the unfiltered smoke which has the same stain intensity as the penetration test stain is found and the percent penetration defined as:

$$\frac{\text{Volume of Unfiltered Smoke Aliquot}}{\text{Volume of Filtered Smoke Used}} \times 100$$

This method gives only a relative measure of penetration since the efficiency of the test strip paper is a function both of the particle size of the smoke and the flow rate, and these conditions are quite different when sampling filtered and unfiltered smoke.

Standard adapters have been made to test either canisters or an area of 100 sq. cm. of filte : paper. The flow rate through the apparatus is 32 liters per minute. Figure 5 shows this test machine.

Dioctyl Phthalate Test - J. W. Thomas

The dioctyl phthalate (DOP) test is used for determining penetration of filters by liquid smokes. DOP is a high boiling point liquid, $C_6H_4(COOC_8H_{17})_2$. The non-toxic, homogeneous liquid smoke is generated by suddenly quenching 20 liters per minute of air containing DOP vapor at 170° C with 80 liters per minute of air at about 25° C. The mass concentration obtained is about 100 micrograms per liter. The particle size generated (about 0.15 microns) is determined by measuring the degree of polarization of light scattered at right angles.

A photoelectric pentometer is used to measure penetration. The instrument is adjusted to give 100 % reading when unfiltered smoke is passed through the smoke cell. Subsequently, filtered smoke is passed through the smoke cell and since the intensity of scattered light is proportional to the smoke concentration, the output of the photo tube is the measure of penetration. Penetration may be measured to at least 0.01 %, corresponding to 0.01 micrograms per liter.

The test comes a lot closer to measuring absolute penetration than the m.b. test, si..ce a uniform particle is used and one does not depend on a paper filter for collecting the smoke. Either canisters or filter papers may be tested. This canister testing machine is shown in Figure 1.

Gas Sorption Theory - J. W. Thomas

There are two main processes occurring in the sorption of a flowing

FIGURE I. DOP APPARATUS

gas-air stream through a charcoal bed. The first process is the diffusion of the gas molecule from the void space in the bed over to the surface of the charcoal granule. The second is the sorption of the molecule on or in the charcoal granule on arrival. One or both of these processes may be the "rate controlling" step which determines the efficiency of the bed.

For gases such as chloropicrin, at least some of the available charcoals can react so rapidly that the limiting factor in the removal of the gas - the rate of diffusion to the granule - has been reached, and further improvement of the adsorbent will not result in a higher bed efficiency. For other gases, the processes occurring on or in the granule are rate-controlling, and improvement of the adsorbent will result in higher bed efficiencies.

A plot of "life" (length of time an adsorbent will prevent the passage of more than a specified concentration of gas) against bed depth will always result in a curve (or straight line) intersecting the bed-depth axis at a finite value. It follows then that there exists a critical bed depth below which the life is zero, and that doubling the bed depth will more than double the "life" to a specified effluent concentration.

Methyl Iodide Test on Charcoal - J. W. Thomas

Inert sodium iodide was added to an aliquot of a 120 millicurie shipment of I_{131} from Oak Ridge, and dimethyl sulfate added to the solution in a distillation apparatus. Radioactive methyl iodide, boiling point 42° C, was distilled over into a receiver. Several runs were made, the activities obtained being from 1 to about 20 microcuries per gram of CH_3I.

A concentration of 20 milligrams of CH_3I per liter was set up by passing an aliquot of the entering dry air stream over CH_3I, and a total of 32 liters of gas-air mixture passed through the test canister (an Army Assault Canister). The gas concentration, both influent and effluent to the canister, was measured radiometrically and chemically. The gas was absorbed by liquid bubbler scrubbers. Representative figures obtained on the penetration were: (1) 40 minutes life to an effluent concentration of 0.02 milligram per liter; (2) 42 minutes to a concentration of 0.01 milligram per liter; and (3) 45 minutes to 1.0 milligram per liter. Tests were made at various activities of CH_3I up to about 20 microcuries per gram and no effect due to radioactivity was found within the experimental error of the test (probably = 10%). Further work at the Army Chemical Center is planned at higher activities.

Even at these relatively low levels of activity shielding problems were troublesome; when a new test is planned it would be desirable to use a pure beta (or alpha) emitter. This would permit high specific ionization on the charcoal granules with a minimum of shielding problems.

A preliminary report has been written and should be available soon.

Sodium Iodide Test on Cml. Corps # 6 Paper - J. W. Thomas

A solution of inert sodium iodide containing an aliquot of a shipment of I_{131} from Oak Ridge was atomized, producing a heterogeneous solid smoke after mixing the stream from the atomizer with a larger volume of dry air. Samples of the smoke were taken through filter paper both before and after passing the main stream of smoke through a 100 sq. cm. area of Cml. Corps # 6 paper. The percent penetration was taken as being the counting rate of the effluent sample paper divided by the counting rate of the influent sample paper times 100.

Runs were made at different microcurie levels. Some were made using "carrier-free" material, i. e., no inert sodium iodide was added.

A preliminary report has been written on this work and will soon be available.

ORNL Pile Filter House Efficiency Study - I. Spiewak and C. P. Coughlen

The filter house inlet and exit air streams were sampled through a number of Cml. Corps # 6 filter papers in series. The papers were counted and analyzed radioachemically by the Chemistry Division for some of the major rare gas fission product chains. The results of the analyses were:

	Activity at Pile Exit Curies/day	Activity Past Cm. Corps Filter Curies/day
Krypton 89	12.5	12
Krypton 91	200	34
Xenon 140	45	19.5
Xenon 141	150	0.2

The papers collected before and after the filter house indicate an overall house efficiency of about 91 percent on gross beta contamination potential. The actual house efficiency on particulates is in the neighborhood of 99+ percent, but a considerable quantity of gas decays to particulate matter after the filter house. This is in the order of one millicurie per day of long-lived beta emitter, or 5 - 10 millicuries per day of short-lived particulate activity.

A diagram of the sampling unit is shown in Figure 2. The sampling flow was 4.8 cfm out of 100,000 cfm pile air. The upstream and downstream units were located 4.8 sec. and 46.3 sec., respectively, after the pile exit; flight time through the units was 10.9 seconds. The duration of each run was about three days.

Table I is a summary of the activity observed on the papers after removal of the apparatus. The papers are numbered from left to right as shown in Figure 2.

Table I

Beta Activity on Cml. Corps Paper*

	House Inlet			House Exit		
Paper	Run 1	Run 2	Run 3	Run 1	Run 2	Run 3
1	29748	134367	43404	5478	4514	4021
2	508	796	579	1086	632	373
3	261	418	423	636	315	---
4	9555	8006	13996	2852	1265	3288
5	---	78	959	---	153	134

The inference from these data about the filtering characteristics of Cml. Corps paper is that its efficiency on small newly formed radioactive particles is low. There is definite evidence of decay in flight of rare gases, as no uranium particles were found after the first filter paper. These decay products, charged positively, are apparently difficult to filter.

*Based on 1 sq. in. at 6.1 percent geometry.

SAMPLING APPARATUS

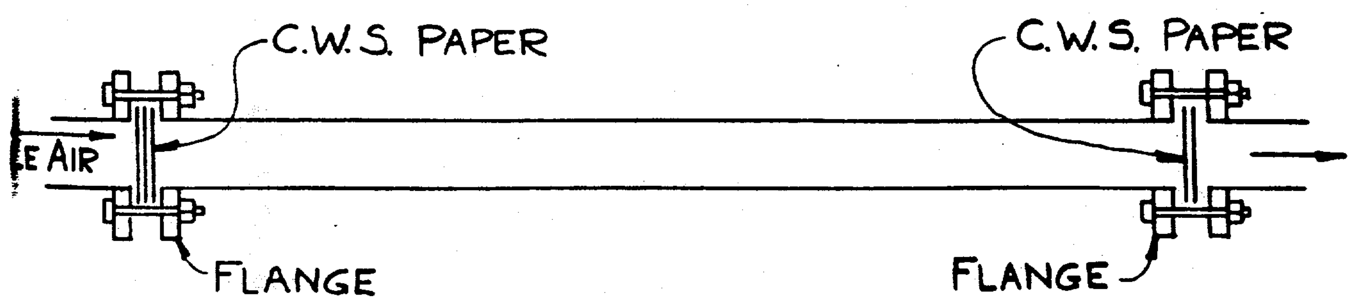

FIGURE 2

ORNL Experimental Studies J. W. Gost

The approach to the problems has consisted mainly of visual and microscopic (optical and electron microscopy) examinations, X-ray analysis, radioactivity measurements, radioautographs and decay characteristics.

Cascade Impactor Studies. Runs were made on pile effluent during the pushing of 441 slugs in November, 1948. Analysis of the data indicates the following: (a) that greater quantities of large particles (larger than 4 microns) are released during slug disturbance operations than when the pile is operating normally; (b) that increased amounts of large particulates are blown out of the pile when pile cooling air velocity is increased; (c) that the particulates released during "pile-off" operations appear to have a rather long half-life; (d) that short-lived material escapes mainly when the pile is "on" and this material is largely the daughters of gaseous fission products, molecular in size before agglomeration; and (e) that some of the smaller particles may adhere to larger ones.

Filter Media Studies. Looking to small fiber diameters as well as their compactness as an index of filtering efficiencies, electron micrographs revealed that: (a) the American Air Filter FG-50 fibers varied in width from less than 1 micron up to 5 (some were found to be 20mm long); and (b) Cml. Corps # 6 paper fibers varied in width from approximately 0.1 micron to 20 microns. The smaller ones were asbestos and the larger were hemp or cotton binders which constitute 32 percent of this filter material.

The Use of Roughing Filters. Cml. Corps # 6 paper was known to have a high filtering efficiency and also a rather high "plugging" rate. In order to remove the bulk of the filtered material first, thus giving a longer filter life to the Cml. Corps filters, it was decided to use AAF FG-50 as a roughing filter. On the basis of the Chemical Corps test it was thought that 2 layers of the FG-50 as prefilters would prevent a high pressure drop in the Cml. Corps # 6 paper. It is suggested that the Y-12 filter group might study the penetration, plugging and life characteristics of roughing filters as they apply to the problem of prefiltering.

Calculated Decontamination Factors. On the basis of results obtained with a laboratory scale set-up, the following Decontamination Factors are to be expected on the ORNL pile filter house:

Table II

Particle Size in Microns	Filter Media FG-50	Cml. Corps # 6 Paper	Total D. F. across Filter House
0.3	10	3.1×10^3	3×10^4
0.8	1.7×10^2	3.5×10^4	6×10^6
6.0	unknown	infinity	infinity

Particle Studies. Following the installation of the pile effluent filter house at ORNL, large particles (of the order of several hundred microns in diameter) continued to settle on the ORNL area but at a reduced rate. Microscopic examinations suggested the possibility of their being large concrete particles with smaller particles of UO_2 adhering to them. Examination of some ductwork substantiated this. Attempts are now being made to positively identify these small specks adhering to the larger particles.

Plugging of Filters. Studies have been, and are being made of the FG 50 and Cm. Corps # 6 filters in an attempt to explain the plugging observed.

a. Soluble and Insoluble Solids in H_2O. It has been estimated that 50 percent, or more, of the plugging noted on the influent side of the FG-50 is due to the residue left when water is evaporated in the pile air stream to cool the effluent air.

b. Fly Ash. Electromicrograph comparison of used Cml. Corps #6 filter paper and samples of fly ash from the power house have revealed a striking similarity. Together with other data, it was concluded that fly ash from coal burning installations contributes to the plugging of these filters.

Penetration of FG-50 Filters. The examination of two samples of used FG-50 filters (one having been in the effluent air stream of the pile for 44 days and the other for 94 days) showed the following: (a) most of the radioactivity was on the effluent side of the first layer; (b) some active particles have been found in the second layer; and (c) there was good evidence of leakage around the frame gaskets.

Radioactivity Measurements on Used # 6 Paper in Cml. Corps. Filters. These measurements have shown that from 1/4 to 1/2 of the activity which is in the pile filter house is being removed by the Cml. Corps paper filters.

Radioautograph techniques have also revealed a flaw in the present spacer arrangement of the Chemical Corps Filters.

Efficiency of Pile Effluent Air Filter House. In all of the attempts at determining the efficiency of the pile filter house, the problem has been made complex by the decay in flight of the gaseous fission products into particulate daughters. However, all tests show a high degree of efficiency for non-gaseous particles. Electromicrographs of the fourth paper (see Figure 2) in a series of five, both before and after the filter house, showed no particles present at the magnification required for 0.1 micron particles, which tends to confirm previous results that all the activity on these layers comes from atomic or molecular particulate daughters of gaseous fission products.

Decay Studies on Used Filters. Two layers of used FG-50 and one of used Cml Corps # 6 paper which had been exposed to pile effluent air for 476 hours of "pile-on" time were examined. Both layers of FG-50 and the influent side of # 6 paper showed visual evidence of penetration. Radioautographs after six months of decay showed almost no activity remaining on the # 6 paper and the second layer of FG-50 while the first layer of FG-50 still showed considerable activity.

Air Monitoring Devices, Vacuum Cleaners and Filters. The use of filter paper in these devices in the normal activities of all AEC installations has presented some problems. The majority of commercial vacuum cleaners on today's market have a distinctly inferior grade of filtering media. It is likely in some instances that the mere use of one of them presents a hazard; much of the contaminated materials is dispersed back into the room atmosphere as a finely divided aerosol. Examination of the bags used at ORNL in an Airway Cleaner by the Chemical Corps (by the use of their DOP techniques) showed that from 85 to 90 percent of 0.3 micron particles passed through. Examination of the Filter Queen filter showed that it is possible for a 100 micron particle to pass through. It is suggested that the m.b. machine to be installed in Y-12 might be used to study the efficiencies of filter media in these devices.

Protective Equipment

a. Gas Masks and Canisters. Examination of an E12R3 particulate canister by radioautograph after its use in removing filters from ORNL pile filter house showed some radioactive particulate matter on the first Cml. Corps # 6 paper layer.

b. Respirators. DOP penetration tests of the filter media in the MSA "Comfo" type respirator showed 35 to 75 percent penetration under varying conditions.

c. Nasal Filters. Study of the filter medium in a nasal filter after 5 weeks of wear showed two radioactive particles. This period covered approximately 6 hours breathing time per day on what was assumed to be non-hazardous air. Health Physics calculations showed that 1.5 particles should have been present in the air breathed.

Dynamic and Electrostatic Precipitators. - J. W. Morfitt

There are two types (other than mechanical filters) of devices which can be used for collective protectors in filtering air-borne contaminants from the air in buildings and other installations. Although manufactured under a number of trade names, one may note two general classes, viz., dynamic and electrostatic precipitators.

The dynamic precipitator separates out solid particles by centrifugal action. In the "Rotoclone", Type D or F, the dust laden air is sucked into the center of a core of rotating fan blades from which point the curved fan blades force it toward the rear wall of the fan casing. Here the exit air stream is split into two parts by a partition located in the housing or by the shape of the fan housing itself. The particulate matter, together with a small volume of the original air, proceeds in a slowly moving stream parallel to the surface against which it was thrown by the centrifugal forces; the main stream of air, now free of a large part of its suspended matter, is blown through the exit duct by the action of the fan. Manufacturers of this device and other similar devices expect at least some significant removal of particles down to approximately 8 microns in diameter. By adding a water spray to the exit air of one of these devices one can expect to approach a limiting particle diameter of one micron, again according to manufacturing claims.

A variation of the water spray technique is exemplified in the Type N "Rotoclone". In this type, a fan is used to move the air but there are no other moving parts. The moving air must pass through a specially designed sinuous passage submerged in water. This motion of the air forces the liquid in the passage to form two separate sheets of water through which the air must likewise pass to leave the unit. The combination of centrifugal action and water scrubbing provides continuous cleaning of the air. Other liquids may be substituted for the water.

[redacted]

Another filtering device, the "Multiclone" is claimed to give significant separation down to particles of one micron. The unit consists of a hollow cylinder (3" - 9" in diameter) with a conical bottom. The dust laden air enters tangentially to the cylinder at the top of the chamber which is specially shaped to induce a vortex action. The suspended material is then thrown against the sides by centrifugal action and spirals down into a collector at the base. The clean air in the center of the cylinder leaves by a separate port.

Of these three types of dynamic precipitators, the Rotoclone, Type N, is the only one used at the Y-12 Plant with small particle recovery in mind. In this connection, such a unit is used to scavenge the air passed by some Cottrell Precipitators. Ordinarily, the Rotoclone would be installed in front of the Cottrell since the Cottrell is supposed to operate more efficiently on the smaller particles. The Rotoclone did remove material which escaped removal in the Cottrell, probably because the inertia of the large size particles was too great and the time of influence too small to be removed by the Cottrell. In any event, the experience at this plant would tend to conclude that some sort of finishing filter is always necessary to back up the Cottrell.

In the case of electrostatic precipitators, arcing will lower the field temporarily and allow some particles to pass. Secondly, although the deposited material can be continuously removed by allowing a weak acid solution to flow over the inside surfaces of the tubes, the units will have to be shut down periodically for a more thorough cleaning.

The experience with electrostatic precipitators at Y-12 has largely been obtained with the use of Westinghouse Precipitrons in Building 9212. There are twelve large units, consisting of 16 cells each, handling a total flow of approximately 240,000 cfm. It is not possible to make a fair evaluation of their performance, since the engineering of the original installation leaves some things to be desired. Furthermore, the units handle general building exhaust and no measurements have been made to determine the particle size or dust load going to the precipitrons. However, certain disadvantages of such a fixed collective protector have become apparent. In the first place, the collecting plates of 302 stainless steel have been subject to the corrosive attack of the acid vapors present in the exhaust air. This condition can cause thinning and warping of the plates and, in extreme cases, vibration of the plates induced by the flow of air. Such conditions will effect the efficiency of the collector. Secondly, the units are not simpler to handle than filters. The units must be cleaned periodically with a steam hose to recover valuable materials and to keep stack air as clean as possible. The possibility of creating a health hazard during

[redacted]

the cleaning process must be carefully avoided, there being no advantage to using a filter which removes active material from an exhaust system only to release it back into the system during cleaning and recovery processes. Units of the self-cleaning type where plates are periodically and automatically immersed in an oil bath (or some similar decontaminant) would be of the greatest advantage.

Air Monitoring Devices - E. G. Struxness

Application of the Filter Queen Vacuum Cleaner to a device used in air sampling has been in use since 1944 at this site as well as others. A "bird cage" sampling head is employed to contain the filter paper. The type paper usually used is Hollingsworth and Vose # 9081 or # 70. Studies of the efficiency of this paper were made at the University of Chicago and were shown to be extremely efficient (99.9%).

More recent refinements of air sampling equipment continue to rely on the collection of dust in and on filter paper with the only significant difference being the rate of sampling and in the volume of paper used.

Different types of air samplers presently in use also employ electrostatic precipitation as a means of confining radioactive and inert dusts and smokes to a measurable surface. These precipitators appear to be highly efficient as dust collectors.

Some specific information with respect to the efficiency of these various filter papers used in air monitoring devices would be of inestimable value.

Gaseous Diffusion Plant Problem - A. F. Becher

The BM-21-33 combination respirator is currently in use at the Gaseous Diffusion Plant. There is some question as to the efficiency of this respirator against both uranium hexafluoride and attendant gases and dusts encountered in work at this plant as well as at other sites. It would be of great interest and benefit to have this respirator tested against these agents by standard Chemical Corps methods or improved methods resulting from work in this laboratory.

Another problem of concern to safety engineers and plant management at the Gaseous Diffusion Plant is that of M-11 Assault Canister replacement. It is felt that some information concerning the "life" of this canister would help to decrease plant costs entailed in the provision of this protective device to plant personnel. An arbitrary schedule of replacement is in effect at the present time and it is thought that canisters are being replaced before the normal "life" has expired under their conditions of usage.

Summary of Orientation Conferences - E. G. Struxness

In view of the information which has been disclosed at the conferences, and in light of the group's interpretation of the program as outlined in correspondence between the Chemical Corps and the AEC, it would appear that the primary objectives of this group be defined as follows:

1. Develop a standard procedure, at tracer levels, for testing smoke filters against a selected radioactive smoke to determine the degree of correlation with present Chemical Corps tests.

2. Develop a standard procedure, at tracer levels, for testing canisters and/or charcoal against a selected radioactive gas to determine the degree of correlation with present Chemical Corps tests.

3. Determine if a sorbent layer removes essentially all gas up to the "breakpoint" so that protection will be afforded against the most lethal radioactive gases.

4. Make available to the Chemical Corps any and all information on decontamination procedures.

Following expected results in work toward the primary objectives and pending developments with regard to the availability of time and personnel, it would appear reasonable to define these as the secondary objectives of the group:

1. Determine the effect of intense radioactivity on the mechanism of filtration and gas sorption by raising the level of activity in the above tests.

2. Determine the efficiencies of various types of filter media, viz., glass wool, resin wool, filter paper (Hollingsworth and Vose, Whatman, A. D. Little, Chemical Corps, and others.)

3. Determine the effect on the efficiencies of filters of such variables as moisture, temperature, fiber compression and electrostatic charge.

4. Determine the type of protective device necessary for protection against UF_6 and attendant gases and dusts encountered in certain AEC installations.

5. Determine the "life" of the M-11 Assault Canister against UF_6 and/or HF under exposure conditions encountered at the Gaseous Diffusion Plant.

[redacted]

Y-12 LABORATORY FACILITIES

Originally it had been planned to take over a portion, or the whole of, Building 9211, which building was thought to be ideally suited for work of this nature. However, in view of the reduced activities implied in the revised program such elaborate facilities were not required.

It was then decided that, with certain improvements and modifications, space in Building 9733-4 would be adequate. The use of several laboratories and auxiliary chemical equipment in this building had been discontinued in early 1949. Two large laboratories approximately 30' x 40' were available in addition to an air-conditioned balance room, a shop, one conference room and three small offices.

Laboratory No. 1 was designated as the laboratory in which gas testing and associated activities would be carried on. Two 12' stainless steel hoods with the required utility services (air, vacuum, electricity, water) were installed and are 95 percent complete at this writing. The exhaust system, shown in Figure 3, is specially designed to permit the use of charcoal bed and/or Type 6 paper filters in removing toxic and radioactive gases and particulates from the exhaust before it is fed into the existing 40' exhaust stack. Compressed air is dried before entering the hood by passing through a silica gel dryer. Incorporated in the vacuum system are two traps in series designed to prevent contaminants from escaping through the vacuum exhaust. A liquid trap removes liquid residues after which a charcoal bed trap, incorporating fiber glass at the influent and Type 6 paper at the effluent end, removes the gases and particulates. A typical trap installation is shown in Figure 4.

The methylene blue and DOP test equipment shown in Figure 5, will be operated in the 20' hood located in Laboratory # 2. Here, also, steps have been taken to remove particulate contamination from the hood exhaust by the filters shown in Figure 3.

In addition to the stainless steel hoods, there are regular chemical hoods in each laboratory with the necessary services. Each of the laboratories are equipped with two 20' double type laboratory benches serviced with gas, air, vacuum, water, and electricity.

The shop room has been air conditioned and is being used as an instrument repair shop. The air conditioned balance room is temporarily being used as a counting room and balance room.

[redacted]

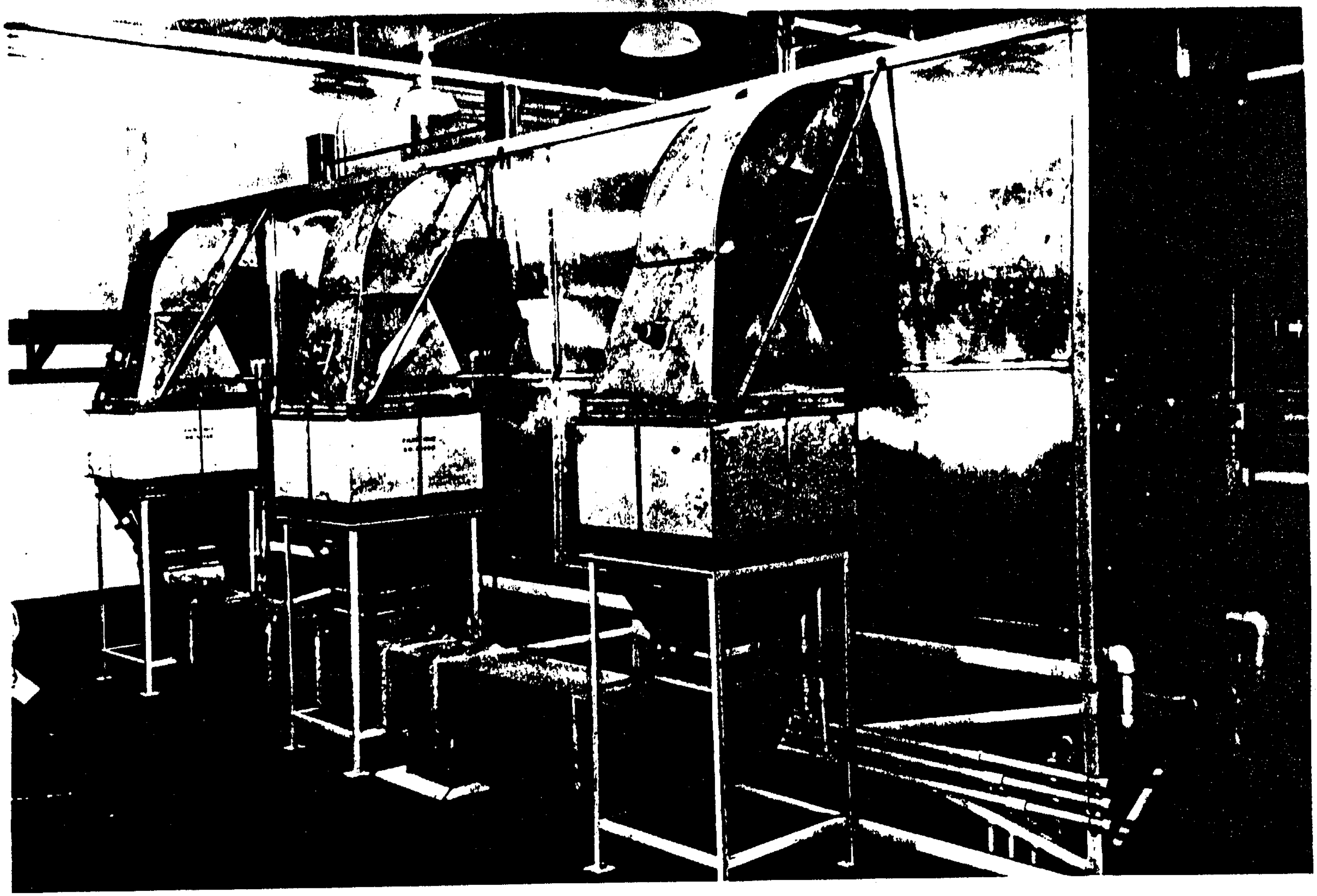

FIGURE 3. VIEW OF HOOD EXHAUST FILTERS

FIGURE 4. VACUUM TRAPS AND AIR DRYER

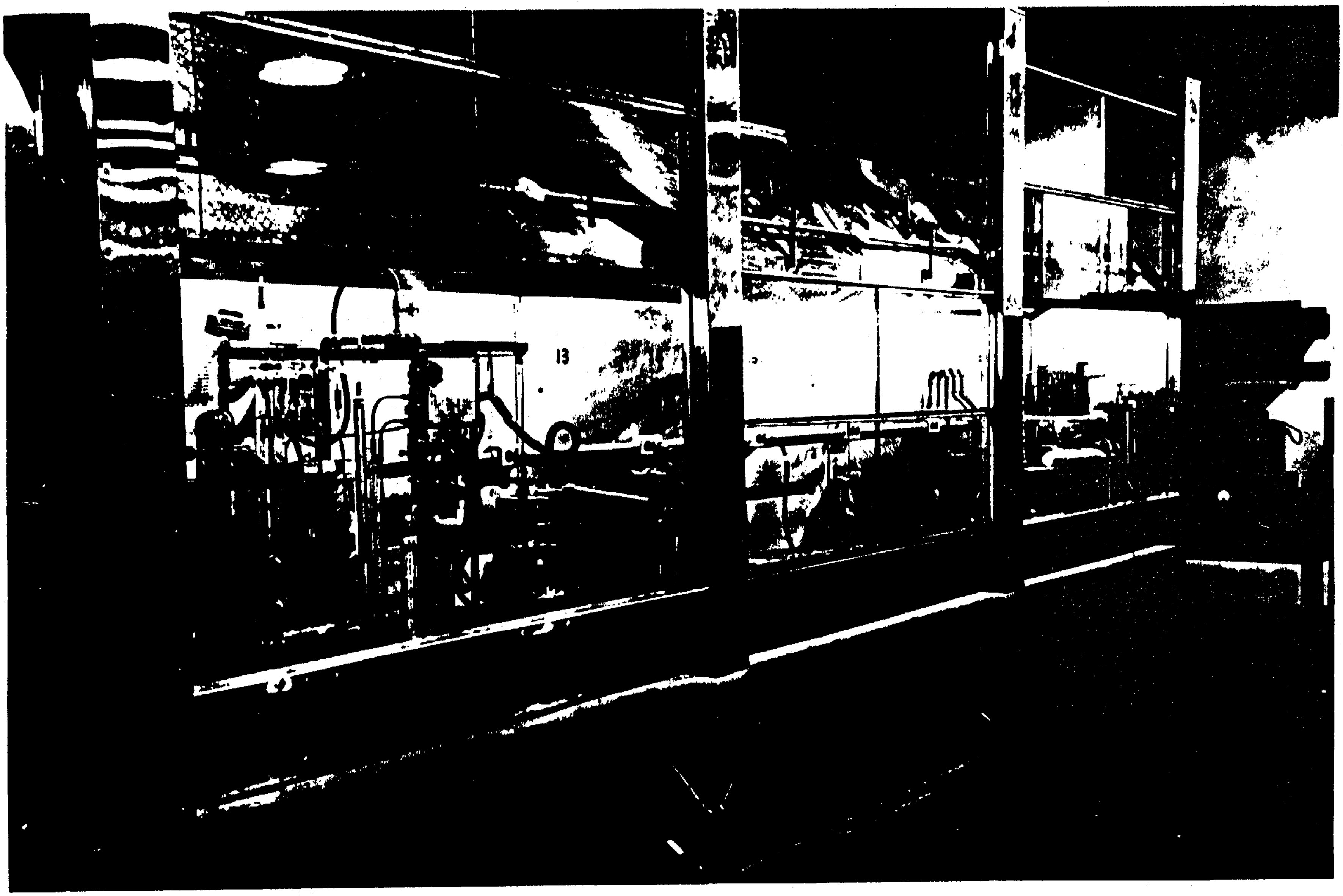

FIGURE 5. FRONT VIEW OF HOOD SHOWING m.b. AND DOP APPARATUS

SELECTION AND USE OF RADIOACTIVE TRACER

Necessity for High Level Tests

To provide protection against radioactive gases and smokes, gas masks and other air cleaning devices must have an efficiency very much higher than the values previously considered adequate.

During World War II, the "breakpoint", that is, the penetration value up to which the military gas mask canister was still considered satisfactory, was set at values over one microgram per liter for all the standard test gases. In the test of the canister filters against methylene blue, the lowest penetration measurable was about 0.005 percent of the influent smoke. Since it is possible to set up smoke concentrations of 20 milligrams per liter, 0.005 percent penetration would correspond to a mass concentration of the order of 1 microgram per liter penetrating the filter.

These World War II tests are far too insensitive to allow a prediction of whether or not a gas mask will protect against radioactive agents. For example, if the sorbent layer of a canister should let through continuously 0.1 micrograms per liter prior to the breakpoint (perhaps due to channeling or leaks), this would not be detected by present methods. This amount would possibly be fatal, since the wearer would breathe about 1000 liters in an hour, or about 100 micrograms. Report M-2721[5] states that extrapolation of mortality figures from rat to man shows that 2.8 millicuries of polonium would be a lethal dose for man. This is equivalent to 0.63 micrograms of polonium. Obviously the penetration of 100 micrograms of some carrier-free radioisotopes would be a lethal amount.

Of course, present military canisters may completely remove all gas up to near the breakpoint, or, for example, all but 10^{-5} or 10^{-6} micrograms per liter, and thus provide protection against even the most lethal radioisotopes, but this has never been determined.

In addition to the extreme sensitivity necessary to evaluate canisters

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(5) "Monsanto Chemical Company, Unit 3, Progress Report, April, 1945" Monsanto Chemical Company, M-2721, April, 1945.

against radioactive agents, there is the added factor of a possible deleterious effect of radioactivity on gas sorption and filtration. Probably the two chief factors here are ionization of the air stream under test and the effect of recoil nuclei from the disintegrating atoms.

It is obvious that it is necessary to work at high activities in order to achieve high sensitivities and to determine the effect of intense radiation.

Isotope Selection

Except for the selection of a particular element for its chemical properties or for its previous use in sorbent or filter testing work, there are perhaps three important physical properties governing isotope selection: (1) half life, (2) type of radiation, and (3) availability.

Half-life. Any isotope with less than one or two days" half-life would be very difficult to use because of the time factor. However, too long a half-life is likewise undesirable, since only a low specific activity is possible even if a pure isotope is used. For example, pure carbon 14, with a half-life of about 5100 years, has a specific activity of about 4 curies per gram. The standard DOP test (dioctyl phthalate, a liquid aersol) uses a mass concentration of 100 micrograms per liter, with penetration usually being less than 0.01 percent of the influent smoke, or less than 0.1 micrograms per liter. Even if all the carbon atoms in every DOP molecule were labelled C 14, the specific activity in the influent stream would be less than 400 microcuries per gram of DOP, and less than 0.4 microcuries per gram in the effluent stream. In a one minute test on filter paper at 32 l/min., only about 1 millicurie would accumulate on the paper. These activities are certainly inadequate for determining the effect of high levels of activity on filtration efficiency.

Moreover, a short half-life is desirable so that decontamination problems may be simplified. The most desirable half-range, considering all features, would be from 5 days to about 100 days.

Type of Radiation. It is felt that the use of gamma emitters is undesirable. The effect of ionization caused by the gamma ray would be far less than the ionization caused in the charcoal or filter by an equal number of beta or alpha particles; due to the penetrating nature of gamma rays most of the ionization would occur at some distance from the material under test. Any recoil effect occurring with alpha and beta emitters would be greater than that occurring with gamma emitters. Also, shielding problems would make operation difficult with high levels of gamma activity.

To achieve maximum ionization and recoil effect, it would seem desirable to use alpha emitters. However, the few alpha emitters available do not have a suitable half-life, are not available in sufficient quantity, or cannot be made into a gas or aerosol conveniently.

The above considerations more or less limit the choice of isotope to a pure beta emitter.

Availability. Some otherwise satisfactory isotopes can be produced only by the cyclotron in minute quantities. Some useful isotopes can be made in the pile but the rate of production is low.

Use of Sulfur 35

The common test gases used by the Cml. Corps are CCl_3NO_2, $COCl_2$, HCN, CNCl, and AsH_3. The common test aerosols are dioctyl phthalate, $C_6H_4(COOC_8H_{17})_2$, and methylene blue, $C_{16}H_{18}N_3SCl\ 3H_2O$. The available atoms, for preparation of radioactive agents, are therefore C, Cl, N, O, H, As, and S. None of these elements except sulfur have radioactive isotopes which are pure beta emitters with a usable half-life. Arsenic 74 has a suitable half-life, 16 days, but has an 0.6 mev gamma ray. Chlorine 36 has a half-life of about 10^6 years, which is much too long to permit adequate specific activity. Carbon 14 is perhaps suitable for gas testing, where gram amounts are used, but its rate of production is low, and decontamination problems would be quite serious. All the other isotopes of the above atoms have very short half-lives.

Sulfur 35, however, has an 87 day half-life, is a pure beta emitter, and is available in carrier-free form (high specific activity, about 40,000 curies per gram). For these reasons sulfur 35 is thought to be a good selection for the test isotope.

PERSONNEL ASSIGNMENT

In the original agreement between the AEC and the Cml. Corps, it was decided that each of the contracting parties would equally share the providing of technical personnel. It was expected that the group would reach a total of from six to ten people during the initial phase of the program.

At the conclusion of this quarterly period, three people were spending all of their efforts on the program. E. G. Struxness, Health Physicist of Carbide and Carbon Chemicals Corporation, had assumed the responsibility of group leadership under the Director of Research, Dr. E. D. Shipley. J. W. Thomas, Chemical Engineer, and Lt. Col. H. P. McCormick, of the Army Chemical Corps, had been on the area since mid-July aiding in problems of organization and laboratory modification. Lt. Col. McCormick is the Army Chemical Corps Liaison Officer. R. G. Orrison, Chemical Engineer, Carbide and Carbon Chemicals Corporation, and R. L. Quinn, Electrical Engineer, Carbide and Carbon Chemicals Corporation, both of whom are expected to begin full time activity with the group in the near future, have been devoting part of their time to work in the laboratory. E. H. Bouton, Chemical Engineer of the Army Chemical Corps, spent one week in September at the laboratory in preparation for his permanent assignment here which will become effective in October.

Edw. G. Struxness
E. G. Struxness

Approved: E. D. Shipley
E. D. Shipley